

AD-A176 323

OFFICE OF NAVAL RESEARCH

SEMI-ANNUAL REPORT/PROGRESS REPORT

for

1 February 1986 through 31 JULY 1986

for

Contract N00014-(84K-0423)

Task No. NR (243-049)

"Diffusion and Defect Characterization Studies of
Mercury Cadmium Telluride"

Principal Investigator: D. A. Stevenson

Department of Materials Science and Engineering
Stanford University
Stanford, CA 94305

Sponsored by Defense Advanced Research Projects Agency (DOD)

Defense Sciences Office

DARPA Order #5019

Issued by Office of Naval Research

SFRCNO. N00014-84K-0423

86 5053

This document has been approved
for public release and sale; its
distribution is unlimited.

86 9 16 156

DTIC FILE COPY

DTIC
ELECTE
JAN 05 1987
S D
E

Cleared
ASD P A
DEC 29 1986

OFFICE OF NAVAL RESEARCH

SEMI-ANNUAL REPORT/PROGRESS REPORT

for

1 February 1986 through 31 JULY 1986

for

Contract N00014-(84K-0423)

Task No. NR (243-049)

"Diffusion and Defect Characterization Studies of
Mercury Cadmium Telluride"

Principal Investigator: D. A. Stevenson

Department of Materials Science and Engineering
Stanford University
Stanford, CA 94305

Sponsored by Defense Advanced Research Projects Agency (DOD)
Defense Sciences Office
DARPA Order #5019
Issued by Office of Naval Research
SFRCNO. N00014-84K-0423



Accession For	
NTIS GFA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	<i>per</i>
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

86 5053

86 9 16 _156

I. Progress During the Report Period

During the last six month period, progress has continued in the two major areas of this program: diffusion studies in Mercury Cadmium Telluride (MCT); and growth studies in MCT. The diffusion studies in the present report period have emphasized the experimental determination of interdiffusion at lower temperatures ($< 450^{\circ}\text{C}$) and the modeling of the defect chemistry of MCT in order to explain both interdiffusion results and the electrical behavior of MCT. In addition, there is continuing progress on the tracer diffusion studies in MCT. In the crystal growth portion of the program, most of the effort has been devoted to the analysis of our previous work. This has resulted in ~~our~~ ^{the submission of} submitting four papers to Journals for review and copies of these manuscripts are enclosed for your information. Work continues on the experimental study of isothermal liquid phase epitaxy (ISOLPE) and on electrochemical studies.

A. Diffusion Studies:

In this report period, we have completed the interdiffusion studies of HgTe-CdTe couples from 600°C to 300°C for both Hg-rich and Te-rich conditions. We have analyzed the interdiffusion coefficients (D) as a function of temperature (T) and composition (X) and we proposed that interdiffusion occurs by a dual mechanism in the high temperature region ($T \geq 450^{\circ}\text{C}$): a vacancy mechanism is dominant in the lower X value region and an interstitial mechanism is dominant at higher X value region. For temperatures below 450°C , we observed a different behaviour from the high temperature region; there is a dependence of D on the component pressures and D increases for higher X values ($X \geq 0.5$). We attribute this to the predominance of the interstitial mechanism in these lower temperature regions. Our model is confirmed by electrical property studies in the literature (1,2,3,4) and by theoretical calculations of defect concentrations (5).

Progress continues on the topic of tracer diffusion in MCT. We are studying the Hg^{203} and Cd^{109} tracer diffusion from 500° to 300°C. We find two to three branches in the Hg^{203} diffusion profile which are associated with species with different diffusion rates. Since evidence for the fastest species does not appear in the preannealed sample, we chose to reveal the slower branches only. We are investigating the Hg vapor pressure dependence of the two slower branches to establish the diffusion mechanisms for them. Our current results ($T \geq 350^\circ\text{C}$) show that the slowest branch is insensitive to Hg vapor pressure, whereas the second fastest depends on Hg vapor pressure in such a manner consistent with a change from a vacancy mechanism to an interstitial mechanism for Hg^{203} when the Hg vapor pressure changes from a Te-rich condition to a Hg-rich condition. Two to three branches were found in the Cd^{109} diffusion profile. We also tried to resolve the slower two diffusion processes. The slowest two were independent of the Hg vapor pressure. We are currently analyzing the theoretical relationship between interdiffusion and self-diffusion coefficients for this pseudo-binary system, with the objective of explaining the branches that are independent of Hg vapor pressure.

We have finished the Kirkendall effect studies and marker experiment, and hope to interrelate all the diffusion studies.

References

1. H. R. Vydyanath, J. of Electrochem. Soc. Solid-State Science and Technology, 128, No. 12, 260 (1981).
2. H. R. Vydyanath, J. C. Donovan and D. A. Nelson, J. of Electrochem. Soc. Solid-State Science and Technology 128, No. 12, 2685 (1981).
3. J. Nishizawa et al., J. Phys. Chem. Solids, Pergamon Press 37, No. 33 (1976).

4. H. F. Schaeke, J. of Electronic Mat., 14, No. 5, 513, 1985.
5. C. G. Morgan-Pond and R. Raghavan, Phys. Rev. B, 31, No. 10, 6616 (1985).

B. Growth Studies

The isothermal liquid phase epitaxial technique (ISOLPE) was used to investigate the Hg corner of the phase diagram and determine Hg-rich interdiffusion coefficients at 450 and 500°C. Good agreement was obtained in each case with data found in the literature.

A slight modification has been made to the theory for the determination of interdiffusion coefficients from isothermal growth kinetics. The raw data were reanalyzed in the light of this revision and used to fit the interdiffusion coefficient under Te-rich conditions to an equation of the form:

$$D_x(\text{cm}^2/\text{sec.}) = 300 \exp(-7.53X) \exp(-1.92\text{eV}/kT).$$

Progress continues on the application of the coulometric titration technique to determine free energies of formation of the tellurides at 298°K. Progress has been slow because of the time needed for equilibration. There are also some questions that persist regarding the stability of one of the Li/Te compounds needed for the calculation, because of conflicting information in the literature

II. Planned Activity for the Coming Period.

The work planned for the future emphasizes the following topics: continuation of the experimental tracer diffusion studies; continuation of the analysis of all diffusion results, including a unified theoretical treatment; evaluation of epitaxial growth methods; and continuation of the electrochemical studies of the thermodynamic properties of the MCT system.

III. There were no changes in the key personnel in the report period.

IV. D. A. Stevenson presented a seminar at the Rockwell Science Center on March 10, 1986: "Diffusion and Growth Studies in Mercury Cadmium Telluride,"

M.F.S. Tang and J.G. Fleming presented Research reviews at Ford Aerospace on July 14, 1986.

Two papers were presented at the Ninth Conference on Crystal Growth June 3-6, 1986, Fallen Leaf Lake, California: Epitaxial Growth of Mercury "Isothermal Liquid Phase Cadmium Telluride," J.G. Fleming and D.A. Stevenson

"Interdiffusion and the Kirkendall Effect in the HgTe-CdTe System," M.F.S. Tang and D.A. Stevenson.